GEOLOGY OF HUMBOLDT COUNTY.

BY

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CONTENTS:

INTRODUCTION.

Humboldt county belongs to that group of Iowa counties known in the various publications of the state as north-central. It lies in the third tier of counties south of the Minnesota line and is almost equally distant from the Missouri and Mississippi rivers, some twenty-five or thirty miles nearer the former stream. The surface is an almost perfect plain; the highest elevation within its limits rises not more than thirty or forty feet above the general level. Nevertheless the west side of the county, as at Gilmore, is higher by about 100 feet than the eastern, and the north side is likewise higher than the south, so that the general drainage, as effected by streams, is from the north and the west. The only streams of any importance are the forks of the Des Moines river with their tributaries. These occupy comparatively narrow channels, cut down from twenty to seventy feet below the level of the general plateau. To the early pioneer the whole county must have appeared an absolute plain—a prairie, covered with grass and flowers, dotted everywhere by unnumbered lakes, or marshes, darkened by their sombre-tinted vegetation, varied with woodland only within the narrow limits of the flood-plains of the streams. Now the whole landscape is that of a cultivated field, adorned on every side with grove and orchard; the ponds and lakes have vanished, or show as mere depressions, where waving harvests of wheat and corn attest the marvelous fertility of the prairie soil. The native woods have been, in large measure, still preserved, at least in area, and, thickened by a growth unchecked by fire, they border

the river channel in many localities much as of yore, contributing wonderfully to the general beauty and attractiveness of this fortunate county. Owing to causes to be set forth by some future student of the political history of the state, the county is among the smallest, includes but twelve congressional townships, while most counties of the state have sixteen and many, twenty. Kossuth, to the north, has twenty-eight, Webster, to the south, twenty, and Wright and Pocahontas, to the east and west respectively, have each sixteen. Nevertheless, within these narrow limits Humboldt county does not lack biologic, geologic and topographic problems of peculiar interest. These will come out as occasion offers, in the pages to follow. The lack of coal in the county and the scantiness of rock exposure have combined to make this county hitherto less attractive to those sent by the state to report on her resources. Prof. James Hall, whose name will be forever associated with all the geologic science of his country, studied Iowa, it is true, but never saw the northwest counties. Worthen, in 1856, under Hall's direction, followed the Des Moines river and proceeded as far as Fort Dodge.* Dr. White, who, as state geologist, succeeded Hall, visited Humboldt county in 1867, remained for a few days only and made a hasty examination of its rocks and soils. His report, published in 1869–70, is still the only account we have been able to find of the problem before us.† Dr. White visited the exposures in the town of Humboldt along the bank of the river, the oolitic beds, the point known since as Dr. Welch's quarry, of which he gives a section, the exposures at Rutland, and certain exposures just west of the Humboldt county line, in Pocahontas county, on Lizard creek. From a mere cursory examination, Dr. White recognized in general, the true stratigraphy of the rocks he saw, and pointed out the fact that their character did not lend much encourage-

*Hall, Geology of Iowa, vol. I. p. 147.

†Rept. on the Geol. Surv. of the State of Iowa, by Charles A. White, M. D., vol. I. pp. 198 199; vol. II, pp. 243-245.

ment to those who even then were seeking coal within the limits of the county.

PHYSIOGRAPHY.

TOPOGRAPHY.

The topography or surface character of Humboldt county is, as already stated, for the most part extremely simple. Nevertheless, its very simplicity must be explained, and for thorough explanation, as men look at such problems to-day, it requires the consideration and study of not less than three determining factors; these are the Kansan drift, the succeeding Wisconsin drift, and the erosion effected by the Des Moines river and its branches and tributaries.

The Wisconsin drift,—for so we name the latest surface deposit by which the entire north-central portion of Iowa has been more or less completely covered,—has been so thoroughly described elsewhere in these reports* that simple mention would seem perhaps sufficient here. To the Wisconsin drift we owe the peculiarly level upland so characteristic of the county. To the same deposit belong, as a distinguishing character, the thousand diminutive, circular lakes or pools which mark everywhere the open prairie; nor less in the southern and eastern townships the undrained swamps and peat-beds, until recently, so uninviting to the farmer; as, also, the larger lakes that once lent their sheen to the beauty of the landscape. Indeed, almost the entire topography is typical Wisconsin, recognizable from the car windows by the intelligent passing tourist.

Not only is the surface drainage of the county thus imperfect, incomplete, but the erosion effected by the smaller streams is in many places likewise peculiar, indicating in unexpected places the comparative newness of the process. For instance, the banks of the Des Moines in Beaver township and elsewhere show, instead of the usual tributary valleys, singular precipitous ravines cut almost perpendicularly

*See, of the present series, Iowa Geol. Surv., vol. VI, pp. 431-476.

into the body of the drift. These extend back from the river only the shortest distance, sometimes failing to reach the margin of a marsh or lakelet lying only a few rods distant. The processes of erosion here, as such things go, are plainly new and recent.

But, however striking such features of Humboldt topography may thus appear, there are some others that are still more remarkable. A moving glacier is nothing if not a gigantic plane which tends to obliterate completely all surface irregularities and to leave just such a landscape as has been described. But to do its work completely the amount of drift carried by the glacier must be large; enough, practically, to fill up the depressions of the topography pre-existing. In the case before us that condition failed. The amount of detritus carried down was small. In Humboldt county the Wisconsin drift-sheet is remarkable for its thinness. Notwithstanding the fact, therefore, that for the county as a whole the Wisconsin determines the dominant landscape type, there are, nevertheless, numerous special localities in which the deposit is either entirely wanting or so thin, so very thin, as hardly to affect the topography upon which it came. It is but a veil, through which an earlier, older sculpture exhibits still its ancient features. This older topography is that of the Kansan drift, carved by all the erosion which everywhere mark that time-worn stratum. The hills in Humboldt county in general, except as otherwise noted, may be said to represent the pre-Wisconsin or Kansan surface. Those near the mouth of Bloody creek may be taken as example, stretching back northwesterly, with long, low valleys between them. The steep river banks everywhere, such as that near the bridge on the east side of the East Fork, in section 10 of Grove township, or that immediately south of the railway tracks in section 24, Corinth township, are Kansan, and have, in all probability, suffered little change in all the years since floods from retreating Kansan ice-fields passed down the valleys. The ridge north of "Owl lake" is Kansan with a veneer of Wis-

cousin on its steep northern declivity. There are even a few scattered hills (or kames?) in the western part of the county probably referable to the same formation. The highest noted is in Corinth township, Nw. qr., Nw. ¼, Sec. 4. This is a gravel knoll, capped by Wisconsin bowlders. It seems to bear no relation to the local drainage system, but the gravel, though not freshly exposed, may be put down as Kansan, judging from what is observed elsewhere. Further details will be given later, when we come to discuss the Kansan drift as such.

As referable to glacial action it remains to mention one further topographic feature marking the surface of Humboldt county. This is a low ridge, generally breaking off rather abruptly on the south, extending east and west across the northern half of the county. To be more explicit the highland referred to is traceable from Wacousta through Delana and across Grove and Humboldt townships; it forms the divide between Bloody and Trullinger creeks; rises abruptly just north of Hardy and forms the plateau on which stands the town of Renwick. This highland carries up the general level of this part of the county some twenty or thirty feet and seems to be morainic in character; referable probably to the retreat of the Wisconsin ice.

The third factor to be considered in discussing the topography of Humboldt county, is erosion, as effected by the principal streams.

The two principal branches or forks of the Des Moines river meet to form the main stream near the southern boundary of the county. The East Fork enters almost exactly at the center of the north line of the county, bends slightly to the east, and flowing southwardly turns west at length to meet the West Fork at a point almost directly south of the point of entrance first mentioned so that the East Fork divides the county from north to south into two almost equal sections. For nearly its entire course through the county the East Fork flows above sandy bottoms. There are no rock

exposures until we reach the south line of Grove township where the stream cuts into the St. Louis limestone, as will be hereafter noted. The valley of the East Fork is narrow, its banks often low and wooded, the erosion of its flood-plains referable in some places at least to waters from the Kansan ice. A good illustration is seen near the town of Livermore. The flat land on the west side of the river is the old Kansan flood-plain, while the hill east of the bridge is a steep bank of Kansan gravel covered by a veneer of Wisconsin drift. The situation is much like that often observed in the loess-covered regions farther south, with the exception that the Wisconsin here takes the place of the loess.

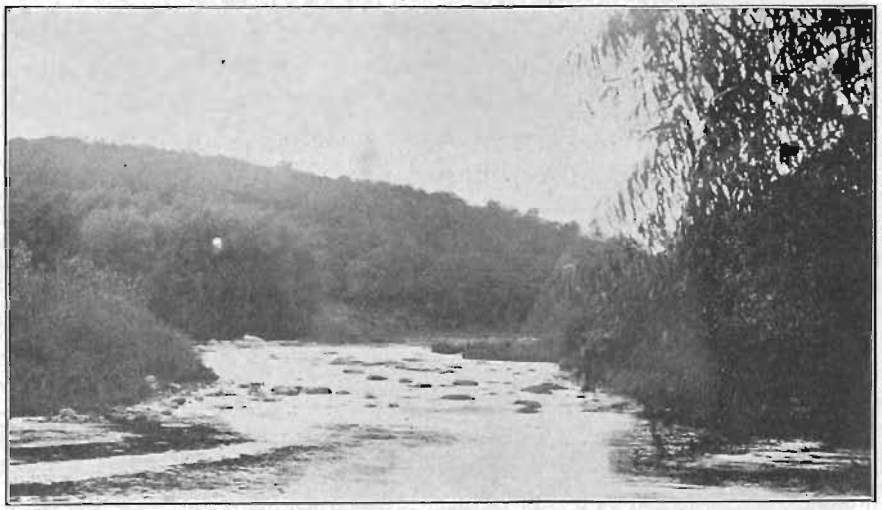

FIG. 12. View of the West Fork Des Moines river, near Humboldt, showing bowlders in river channel.

The West Fork enters the county near its northwest corner, follows the county line southwardly for about one mile, then turns west into Pocahontas county, only to reappear and re-enter Humboldt county five or six miles further south, at Bradgate. The course of this stream, unlike that of the East Fork, is everywhere marked by rock-exposures; the channel is almost uniformly rock-paved and strewn with granite bowlders from the drift, so abundant as to suggest some New

England mountain channel, rather than the quiet, creeping river of the level prairie (Fig. 12). The sides of the stream are limited by rocky walls which become more and more picturesque, more and more prominent topographic characters, as we pass east and south. The banks are, therefore, generally well defined; floods seldom rise above them, and the valley across which the present channel passes, now to this side, now to the other, seems old and long unflooded. In fact, the flood plain, nowhere wide, perhaps less than a mile at its widest point, southwest of Rutland, shows everywhere a shallow deposit of sand and gravel referable again to the Kansan drift, with only here and there a scattered bowlder or group of bowlders, to indicate that ever the Wisconsin had come and gone. It is difficult to reconcile the situation thus described with our pre-conceived notions of glacial activity. It may be, however, suggested, that the on-coming of the Wisconsin ice was slow; the valleys in question were slowly filled, while later accumulations, moving southwards, passed over the valleys entirely. At any rate, the later ice-sheet in many parts of the Humboldt county valleys, seems hardly to have moved at all, and in such places the deposits of drift are insignificant.

The secondary streams of the county present few topographic features of special interest. They are in general typical prairie streams, with shallow channels, low gradient, and accordingly show erosive characters only as they near the flood-plain of the receiving rivers, as already mentioned in the case of Beaver creek and Bloody run. The principal secondary stream of the county is Lott's creek, which, with its tributary Trullinger, drains the northern part of Delana township, and is reported to be a perennial stream, especially below its junction with Trullinger. Lott's creek empties into the East Fork just north of the town of Livermore, and its banks, especially west of that village, exhibit the characteristics already described as forming a Kansan landscape.

DRAINAGE.

As already intimated the drainage of the county, as effected by natural channels, is quite imperfect. The general slope of the west half of the county is from west to east. Gilmore is more than a hundred feet higher than Dakota City; the east half shows little variation, is almost level, with only a slight fall toward the Des Moines river to the southwest, and toward the Boone river to the southeast. The early settlers occupied the higher ground to the north and west, leaving the great swamps of the east and south as a problem for later comers. It is hardly necessary to say that the problem has been quite effectively solved. Ditches and tile drains have worked marvels, and will no doubt eventually bring almost the entire prairie under the plow. Even considerable lakes, respected of the United States surveyor, which might have remained to lend charm and attractiveness to the otherwise monotonous landscape, have yielded to the spirit of conquest which would bring every foot of nature's domain under man's control. Owl lake seems to have been a beautiful and permanent sheet of water, covering several hundred acres, ten or fifteen feet deep, bordered by beautiful groves of native trees. In draining a great marsh which lay to the south, and which, if reports are true, might better have found outlet by Beaver creek, Owl lake was put in the line of the ditch, and the waters from both regions carried into Boone river. The fact illustrates well the topography of this part of the county; the drainage canal might have gone at least equally well east or west, and there is not in either direction sufficient fall to have brought about natural drainage. The drift is, in the neighborhood, very deep. A well, wholly in the drift, near the south margin of the lake-bed, is 118 feet deep. The water rises from beneath a bed of organic matter, which doubtless represents here the pre-Kansan surface forest-bed. A well in the middle of the former bed of Owl lake is said to be sixty feet deep.

Drainage by ditches is, however, characteristic rather of the eastern and southern portion of the county. The western, and especially the central townships, exhibit a very different system, in some of its features unique. The limestone which underlies the region now in question appears to be full of fissures, and as a result we have subterranean drainage. In numerous places, instead of the ordinary lakelet or pond characteristic of the Wisconsin drift, we have a sink-hole. The lakelets ("kettle-holes") are not wanting; but the great majority of them leak, and drain effectively the contiguous lands. Within the past few years the farmers, taking their cue from the natural state of affairs, have begun boring holes in the bottoms of the marshes or lakes not having such outlets by nature. It is found that a well deep enough to furnish an inexhaustible supply of water will also, on the other hand, receive any amount of water that may be poured into it, and deep-well drainage has become a singular characteristic of the agriculture of Humboldt county. Once a well is sunk in some particular slough, other wet acres in the neighborhood are, by tiling, brought into connection, so that sometimes a single well will drain a very large area, several hundred acres. In every case, of course, the well must reach an aquifer, or water-bearing stratum. The depth to which such wells are sunk varies but little in a given area; the average depth of a large number sunk by Mr. Charles De Groote is about 100 feet. On the other hand a well sunk in the town of Humboldt, to drain the stone quarry operated there, is 185 feet deep, and inefficient. Drainage wells are five inches in diameter, cased from the surface to the rock, and often without so much as a screen at the top. Soil, sand, clay, and detritus of all sorts seem to be received with impunity. The propriety of sending the discharge of unfiltered surface waters into the water couches that must supply at the same time the wells and springs of the county, is, perhaps, a matter that will one day merit consideration at the hands of the sanitary engineer.

STRATIGRAPHY.

Formations Represented.

The geological formations represented in Humboldt county are not numerous, and yet more so than one might at first suppose. Here and there within the county appear the edges (outlying traces) of several of the paleozoic formations that are well developed, and well exposed further to the south. In general, however, vast beds of drift cover all the older formations of Humboldt county, removing them entirely from ordinary exploration, leaving us to guess the extent of their presence from the few exposures along the rivers, where recent erosion has uncovered for a little way these ancient layers. Sometimes, also, the comminuted drill-chips, preserved by an intelligent well-digger, are brought to our assistance, but the data so obtained are not very helpful in identification, and can do no more than confirm conclusions elsewhere more happily formulated. In any event the distance between exposures is, in the case before us, so great that the identification of strata, on grounds lithological only, becomes a matter of some uncertainty. Added to this there is every indication that in the intervals of deposition the succeeding paleozoic strata suffered enormous erosion; everywhere is want of conformity, continuity, offering to the student a problem of no little complexity. So far as at present appears, the geological formations of Humboldt county may be tabulated as follows:

Synoptical Table of Geological Formations.

GROUP.	SYSTEM.	SERIES.	STAGE.
Cenozoic.	Pleistocene.	Glacial.	Wisconsin.
			Buchanan gravels.
			Kansan.
			Aftonian?
			Pre-Kansan?
Paleozoic.	Carboniferous.	Upper Carboniferous.	Des Moines.
		Lower Carboniferous or Mississippian.	Saint Louis.
			Kinderhook.

GEOLOGICAL FORMATIONS.

CARBONIFEROUS SYSTEM.

MISSISSIPPIAN SERIES.

KINDERHOOK LIMESTONE.

The Kinderhook limestone was recognized in Humboldt county by Dr. White.* This observer, however, included under the name all the stratified limestones of the region. Facts now patent to every student, but inaccessible at the time of Dr. White's visit to the county, make it plain that the Kinderhook is really much more narrowly limited than was at first supposed, and is in fact represented by the lowest strata only of the Humboldt county limestones. For its identification we must depend upon lithological characters chiefly; organic remains being few and poorly preserved. But the beds in question are oolitic, and in this respect resemble beds of recognized Kinderhook age in Des Moines and Marshall counties. Besides, the organic remains, such as they are, are undoubtedly such as characterize the Kinderhook strata of Illinois, where these were first described. In the University geological collections may be seen *Loxonema yandellana* Hall?, *Straparollus macromphalus* Winchell, *S. obtusus* Hall, *S. planispira* Hall?, *Omphalotrochus springvalensis* White, *Bellerophon sublaevis* Hall, a small Allorisma and some other undetermined species. These specimens are from the Humboldt beds of oolite, and were deposited at the University by Dr. Clark, of Humboldt, who collected them.

Oolite limestone, as the name suggests, is composed in large part of minute ovate, or egg-shaped calcareous grains or granules, held together by a cement or matrix of similar material. The granules show a concentric structure, and seem to have been formed from what may be termed calcareous sand, each grain first rounded by attrition, then coated by successive layers of lime precipitated from solution.

*Geology of Iowa, by Dr. Charles A. White, vol II, pp. 244-245. 1870.

Oolite is forming to-day along many tropical shores. The process takes place chiefly in the littoral zone, between high and low tide, wherever the beach is covered with fine calcareous sand. Such sands originate along the beaches of low islands, or other land areas that send no gross products of mechanical erosion to the sea, provided the adjacent sea bottoms support coral reefs or other profuse growth of lime-secreting organisms. Waves pound to pieces the structures reared by living forms; and the fine calcareous grains to which these structures are evidently reduced, are strewn over the sea bottom up to the limits of high tide. Winds may carry them inland and pile them up in heaps and wreaths, far beyond the limits of tidal movements; but between tide-marks the grains are alternately moistened and dried, a pellicle of lime carbonate is left upon each calcareous sand grain as a result of evaporation of the saturated sea water, the grains grow by accretion after each retreating tide, and are at length converted into the perfectly rounded ooliths that give character to this particular type of limestone. The very processes, however, which produce calcareous sand, would destroy as well the remains of all forms of living things, and the paucity of fossils is, perhaps, in this way explained.

Exposures of Kinderhook limestone occur at intervals along the banks of the west fork of the Des Moines river, from Humboldt city to Rutland. Within these limits the rock varies in character, very often and very much. These variations depend upon the relative amounts of cement and oolitic material present in the several cases. Thus the rocks by the river at Humboldt, near the abandoned limekiln, show the following section:

		FEET.
6.	Drift, with gravel and rotten bowlders	1–2
5.	Traces of ferruginous sandstone	1
4.	Oolite; the ooliths fewer, irregular, uneven: the rock crystalline	2
3.	Oolite: the ooliths of great uniformity, comprising nearly the whole mass of the stone	8–10
2.	Oolite; the granules of uneven size, irregular	2
1.	Fine-grained "lithographic" limestone, of unknown thickness, at the water's edge.	

The term lithographic, as here used, was employed by Worthen* in describing what is deemed a similar rock in the Kinderhook of Missouri and Illinois. The rock is an exceedingly hard, fine-grained limestone, of a pale drab or bluish-gray color, breaking with irregular, angular or conchoidal fracture and remarkably smooth surface. It appears to have been laid down in deep water, is only rarely fossiliferous, and is composed entirely of only the finest sort of calcareous detritus. In its pure form this kind of rock occurs again and

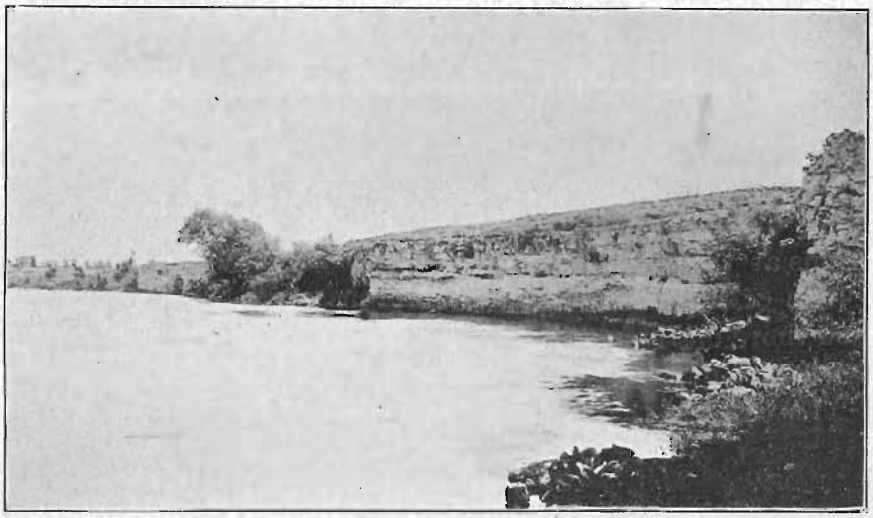

FIG 13. Exposure of Limestone near Rutland—probably Kinderhook.

again in the Saint Louis beds, as we shall presently show; in the Kinderhook it seems to be affected generally with oolitic concretions.

The oolite in the vicinity of Humboldt affords beautiful illustrations of rock of its type, but the beds exposed are of very limited extent. Along the river front they are traceable for a short distance only, within the city limits, and are well seen where the rock has been extensively used for lime-burning. North of the town, in a field adjoining, on the east, the city cemetery, is a small quarry of oolitic stone, but here the

*Geol of Illinois, vol. I, p. 114

oolites are much larger, and the rock of coarser texture. In fact as we go north and west from Humboldt the oolites become larger. At the same time they become fewer in proportion to amount of cement material present, until they cease to be a conspicuous feature of the rock at all. The conditions of rock formation seem to have varied everywhere within a short distance.

At Rutland, along the south bank of the river, is one of the most conspicuous rock exposures in the county (see figure 13). The strata here are also believed to be Kinderhook, and probably correspond to the lower beds in the Humboldt section. The beds are nearly horizontal, dip perhaps a little to the east, may be followed for about half a mile eastward where they disappear, probably having been removed by pre-Carboniferous erosion. Westward the same beds may be traced for some distance along the stream, but are replaced by Saint Louis at the water's edge in section 23 of Avery township. South of Rutland there are outcrops of the same rock here and there on the old flood-plain of the river, especially in the northeast quarter of section 30, in Rutland township. The

FIG. 14 Kinderhook opposite Rutland—to show mode of weathering.

Rutland limestone is not bedded, at least not evidently, it checks and cracks in all directions on exposure to the weather (see figure 14). The rock is, nevertheless, very hard, and erosion proceeds but slowly. Under the lens very large ooliths, or pisoliths, appear, from a quarter of an inch to half an inch in diameter, but no traces of organic remains were discovered. The total thickness of these rocks, as exposed at Rutland bridge, is about twenty feet.

SAINT LOUIS LIMESTONE.

Exposures of rock provisionally referred to the Saint Louis age occur in Humboldt county from the mouth of Beaver creek, near the south line of the county, north to Humboldt, and west to Bradgate. All the exposures visited are situated in the valley of the Des Moines river, and have been uncovered by erosion effected by that stream or its tributaries. For determinations of the horizon of these exposures we must again be guided by characters lithological, and by stratigraphical position; no fossils are discoverable to guide us in our researches. Unfortunately, too, the rocks in question occupy a position which everywhere marks a period of transition, between the two great series of the Carboniferous system; they are accordingly mixed in character. In the same quarry we have sandstones, or arenaceous limestones, evenly bedded limestones, lithographic limestone, generally in thin, hard seams, pockets of shale and clay. Nor is lacking the peculiar brecciated limestone which, in all other western localities, is held to be a sign of the Saint Louis stage.

Notwithstanding all this diversity the various exposures visited are in general consistent with each other; their strata are, in the main, comparable and lie all above the oolite, and where contact can be observed are plainly unconformable with it.

An exposure along the east bank of the river, near the south line of the county, shows the section following:

		FEET.
10.	Drift, probably Kansan covered by Wisconsin; several feet.	
9.	Traces of Des Moines sandstone	6–7
8.	Thin layers of arenaceous-calcareous rock	6–10
7.	Irregular, heavy-bedded limestone, containing angular fragments of lithographic rock	5–7
6.	Shale, with pockets of clay; of variable thickness.	
5.	A thin parting layer, very hard, dense limestone.	4
4.	Regularly bedded limestones, more or less arenaceous; about	2
3.	Regularly bedded limestones, some lithographic; about	2
2.	Talus covering the layers to the water's edge, say	4
1.	Soft, whitish or bluish limestone in the bed of the river. On exposure turns brown or yellow, and washes readily under the rain. Occurs in layers six or eight inches thick, and is said to overlie blue shales.	

Bed number 1, in the above section, has been extensively quarried from the river channel, and used in construction of dwellings in the vicinity. It is said to be white when fresh, and is easily worked. On exposure to the weather it assumes a yellow color and a chalky surface. The succeeding layers up to number 5 are, as far as observed, alternating beds of lithographic stone and rock of softer texture. That called lithographic corresponds with rock so named in other exposures, is exceedingly hard, fine-grained, breaking with angular, somewhat conchoidal fracture. Number 6 is shale passing into clay, and varies in thickness from two to eighteen inches. Number 7 is the most characteristic and clearly defined member of the whole series. It occurs in layers three to four feet thick, unevenly bedded, more or less brecciated, and breaks off in large blocks as undermined by the erosion of the thinner beds below. On the east side of the river this particular layer may be traced to near the mouth of Beaver creek; it is probably represented by the heavy upper rocks exposed east of the bridge over Beaver creek, in section 32 of Beaver township, and again appears in connection with exposures along the east fork, in section 31 of Grove town-

ship. The same rock appears also at one or two points on the west bank of the Des Moines, as in section 31, Beaver township.

From the point last mentioned, northward, the lime rocks in question are seen no more until we reach the south limits of the town of Humboldt. Any limestones that may have occupied the interval have been completely removed by erosion, and their place supplied by drift or deposits of sandstones and shales representing the Des Moines stage.

On the river bank, near the fair grounds, a quarry has been opened which shows an unevenly-bedded blue limestone affording abundant evidence of flexure, and dipping rapidly southward under the black shales of the coal measures. Near the mill on the east fork, east of Dakota, is another exposure of similar limestone, associated with beds of shale and clays. Both these exposures represent beds below number 7 of the section on page 128.

A very much more satisfactory view of these particular strata is obtained at Dr. Welch's quarry in section 31 of Grove township, above referred to. Here we have an exposure of some sixteen or eighteen feet. Heavy, rather evenly-bedded limestone at the bottom, yields a superior quality of quarry stone. It is impossible at present to determine the thickness of these beds; the exposure at present reveals no more than two or three feet. Above comes a course of shale followed by other courses of thin-bedded limestone, the first of which, about seven feet up, is lithographic. The courses above the lithographic seam show traces of oolite. At length appear sandy fragments, probably of the Des Moines, capped by Kansan drift, one or two feet in thickness. The eastern end of the exposure, only a short distance east, demonstrates the unreliable nature of these strata, and the instability of the earth's crust during the period in which they were laid down. Here the strata of limestone pass into beds of twisted, contorted shale, mingled with blocks of sandstone, loose pieces

of limestone, angular fragments, imbedded in clay. Even the best defined strata are traceable for a short distance only.

Similar rock underlies nearly all of the western part of the city of Humboldt. An exposure is seen in Mr. Bull's quarry near the center of the town. Here we have the section following:

		FEET.
3.	Kansan drift, with bowlders, soil, etc	1-2
2.	Thin-bedded, flinty layers of limestone, passing into beds of clay	2
1.	Evenly-bedded, blue limestone, of variable texture	6

Number 1 rests unconformably upon subjacent limestone rock, and is evidently here, if our conclusions are right, the lowest member of the Saint Louis stage. The uneven floor of the Humboldt quarry is the eroded upper surface of the Kinderhook. The limestone is in some places shaly, but at its best is of good quality, dark blue in color, weathering to buff or pale yellow. It is in many places much seamed by vertical fissures of greater or less extent. In some instances these are packed with crystalline calcite; in other cases the rock is simply oxidized and discolored for the depth of an inch or two on each side of the fissure. Number 2 is variable in the extreme, and apparently valueless.

Other exposures, which we refer to the Saint Louis horizon, are found in the so-called "sandstone quarry" in Rutland, and in Mr. Finch's quarry, at the river's edge, in the Sw. qr. of Ne. ¼, Sec. 23, Avery township. The same rock crops out at the water's edge for the last time on the west fork, just below the bridge, in the Ne. qr. of Nw. ¼, Sec. 17, Avery township. Loose rocks of the same character cover the bottom of the present river channel, from the point last named eastward, nearly to the town of Rutland. Some of the exposures mentioned show, in more or less abundance, the curious structure called, by Worthen,* crystallites. There is probably nothing of crystalline nature about these formations. They resemble crystals in form only, are like the casts of crystals,

*Geology of Illinois, vol. I, pp. 115-116.

but more probably represent slight faults in the material of the rock, faults formed while the material was as yet plastic. The axis of the crystallite is always perpendicular, or nearly so, to the plane of bedding. These forms are now known as Stylolites.

At various points in Weaver township, as in the Ne. qr. of Sec. 9, there are exposures of limestone rock which must be considered here. These are mostly in the form of quarries, originally sink-holes, which have been developed to meet the local demand for rubble stone. From the exposure in section 9, just mentioned, a large amount of rock has been taken. The quality seems to be excellent, and the bedding is such as to make comparatively light the labor of the quarryman. The rock is a rather coarse-grained, crystalline, encrinital limestone, reminding one of rocks elsewhere referred to the Augusta stage, unlike any seen anywhere in the river exposures. Open sink-holes in this neighborhood show almost everywhere rock of the same character, so that it is probable that all the southwestern part of the county is underlain by similar strata, except where removed by pre-glacial erosion. In the town of Gilmore, for instance, a similar rock in the northeast part of the village comes to the surface of the ground, while a few rods west, the town well goes down sixty feet before encountering rock at all. Nevertheless, we may consider this peculiar encrinital limestone as the surface rock for all that part of Humboldt county lying south of the west fork, except the flood plains immediately adjacent to the stream. The same rock extends far into Pocahontas county, and is there exposed in precisely the same way. Thus in Clinton township, in Pocahontas county, one mile west of Gilmore, and one and one-half miles north, is a sink-hole quarry, which for years has been very extensively worked. The Gilmore quarry presents the following section:

		FEET.
10.	Alluvium, surface soil, etc.	6
9.	Coarse sand and gravels, Buchanan gravel.	3
8.	Red clay and rotten bowlders of various sizes, representing the Kansan drift.	2-4
7.	Heavy-bedded, coarse-grained limestone, crystalline, encrinital	20
6.	Blue shales, limestone and clay; very fossiliferous...	2
5.	Lithographic limestone, much inclined to angular fracture	1½
4.	Heavy-bedded, fine-grained limestone, no fossils.....	3
3.	Shaly, thin-bedded limestones, with few fossils.....	1
2.	Coarse-grained, fossiliferous limestone, containing fragments of No. 1, but separated from it by a parting of shale.....	1
1.	Lithographic limestone, fine-grained, and very hard	2

If we may judge from characters lithological chiefly, and from comparative position, the surface rock of the southwest part of Humboldt county is identical with number 7 in the above table. The strata exposed in the Gilmore quarry are the only beds above the oolite which contain fossils sufficiently well preserved to give the student any assistance in determining the geologic horizon. But the fossils in this, our only locality, are poor; those of the limestone imbedded so firmly as to be difficult of extraction, those of the shale fragmentary, flattened and generally imperfect, though very abundant. Long and patient search will be required to secure anything like a satisfactory series. The specimens collected were sent to Mr. Stuart Weller, of Chicago, and identified in part as follows: *Eumetria verneuilana*, *Athyris subquadrata* (*?*), *Spirifer increbrescens* (*?*), *Rhynchonella*—Sp. Concerning their horizon or geologic age, Mr. Weller says: "All these forms indicate a younger age than the Osage, or Augusta, as some prefer to call it, and I think they can safely be referred to the Saint Louis."

This accords entirely with the view we have expressed as to the age of the upper formations in the southern part of the county, as at Humboldt and Beaver creek. The strata exposed in Dr. Welch's quarry, for instance, are the equiva-

lent of the very lowest beds in the Gilmore quarry, or, more likely, of beds still lower down. This conclusion accords likewise with the topographic evidence. The difference in level between the river channel at Bradgate and the Gilmore quarry is at least twenty-five feet; *i. e.*, the last exposure at the river, supposing the strata level, is still thirty or more feet below the bottom of the Gilmore quarry. The encrinital limestones of the Gilmore quarry, and of Weaver township, resemble very much in texture the limestones long known in Iowa geology as Burlington, but the reference of the Gilmore shales to the Saint Louis in so far excludes the Burlington from our problem.

Upper Carboniferous.

DES MOINES.

There is every reason to believe that the Saint Louis strata were no sooner deposited than they became forthwith subject to long continued and enormous erosion. The scant deposits which we have been tracing along the rivers, from the county line north to Humboldt, Rutland and Bradgate, are doubtless but remnants of beds once continuous over the entire region, and possessed of thickness possibly only partially indicated by the piled up strata of the Gilmore quarry. The valleys and irregularities, left as a result of erosion, are now in general buried beneath various sheets of drift; some of them, however, were filled long ages before by the sand and shales of Carboniferous waters. One such erosion valley lies immediately south of the town of Humboldt, and extends nearly to the county line. In the southwest corner of the Nw. qr. of the Se. ¼ of Sec. 12, in Corinth township, is a limestone quarry, as already stated, page 129. Within a few rods south occur beds of black shale, and no more limestone appears until near the mouth of Beaver creek, as heretofore described. Along the east fork the situation is exactly the same, and we have here an interval more than four miles in extent occupied, so far as indurated rocks are concerned,

wholly by sandstones and shales. These represent the upper Carboniferous, and are apparently to be correlated with beds of the Des Moines stage, abundantly exposed immediately above the limestone along the river, south of the county line. Here, again, our decision rests upon relative position and characters purely lithological. Most of the material representing the coal measures has also been carried off by long erosion, so that the outcrops are nowhere important or extensive. We may, however, trace them quite continuously along both forks of the river, especially within the limits above described.

Beginning at the south, the first coal measure exposure within the county is found on the west side of the river, in the southwest quarter of section 29, in Beaver township. The outcrop here is sufficiently remarkable to have long attracted general attention. It is known as the "ore bed" or "lava bed." Contrary, however, to the generally received opinion, the "ore beds" have probably never known heat more intense than that of the Humboldt August sun. The ore, however, is real; it is a form of hematite, iron ore containing aluminum, traces of arsenic, zinc and other impurities. The following analysis made by Mr. T. E. Savage, at the University laboratories, shows the content of our "lava":

	PER CENT.
Iron	50.256
Silica, approximately	15
Aluminum, approximately	4
Zinc	Trace
Arsenic	Trace
Other substances, oxygen, etc., estimated	30
	99.256

A similar ore is not uncommon in rocks of this horizon throughout the world. In the particular case before us the iron was doubtless brought down and deposited with the sand, obtained from the waste and decomposition of older rocks not far away. The sandstone so formed later became checked and cracked in every direction, by slight local disturbances, flexures, etc., while the contained iron was in part leached

out in the presence of decomposing organic matter, only to be redeposited as hematite where oxygen was abundant, as in the cracks and fissures just referred to. Subsequent erosion and washing of the sandstone left the hardier ore behind in angular blocks and plates, box-like cavities, etc., the shape determined by the fissures in which concentration originally took place. The ore contains impurities of such character and amount as to make it intractable, and these, together with the small extent of the ore body, render it of little or no value.

A characteristic exposure of Des Moines sandstone may be seen on the east fork, in the southwest quarter of section 19, Beaver township. Here the Minneapolis & St. Louis railway crosses the stream, and the sandstone outcrop is sufficient in extent and solidity to warrant its use to form the abutment for the west end of the railway bridge. The rock is coarse, heavy-bedded, hard, ferruginous, yellow, and furnishes the best illustration seen in the county of the formation now considered. The same rock crops out along the river, on the west bank, in the southeast quarter of section 18, Beaver township, at the upper end of Riverside park, in the town of Humboldt, and on the opposite side of the river, at various points; also in the northeast quarter of section 34, Rutland township. At the point last mentioned the very ferruginous coal measure sandstones are succeeded on the north by a bed of remarkably clean, sharp, white sand, of unknown depth and extent. This, though closely associated here with the coal measure outcrop, represents evidently an entirely different period of deposition. It is probably referable to the overlying Kansan, and is a most noteworthy deposit.

On the east side of the east fork, in the southeast quarter of section 18, Beaver township, the Des Moines is represented low down along the water edge, and for some distance up and down the stream, by the characteristic black shale of the coal measures. This on the land of Mr. Hermanus Ketman was explored some years ago for coal. A drift was run

in some distance from the river, and some imperfect shaly coal seems to have been taken out, but the prospect was on the whole unsatisfactory, and the work was soon abandoned. On the west fork, in the southwest quarter of section 12, Corinth township, within the limits of the incorporated town of Humboldt, a similar exposure of shale occurs along the river. This, also, was at one time the subject of experiment, and several tons of coal are reported to have been taken out. But the vein seems to have been fragmentary, the coal was soon exhausted, and the enterprise was abandoned. At present there are no exposures by which one can judge as to the real character of this particular member of the coal bearing series. The black shales seem to be capped by soft, sandy material, which speedily weathers to rounded slopes, and the whole surface in the localities mentioned is now grown over with grass and shrubs, down to the water's edge. In fact the sandstones and shales of Humboldt county, so far as studied, seem simply to fill up the erosion valleys of the older strata. They are nowhere continuous for any great distance. They are a part only of the northernmost edge of the productive fields of Iowa, and it seems probable that any coal that may once have found place here was swept away by erosive agencies, acting prior to and during the invasion of the Kansan or pre-Kansan ice.

From none of the exposures of coal-measure rocks and shales were fossils collected. Fragmentary plant-remains are said to have been encountered by those who explored for coal, but no trace of these can now be found.

PLEISTOCENE SYSTEM.

The Pleistocene deposits in Humboldt county, as elsewhere generally in Iowa, consist of sheets of drift, beds of gravel, clay, sand, soil, alluvium, etc. Two distinct formations of such deposits may everywhere be easily discovered, an upper and a lower, or, as sometimes described, a younger and an older. The younger, newer, deposits in Humboldt county belong to

what has been already called in this report the Wisconsin drift, the older to the Kansan.

KANSAN DRIFT.

The vast body of all the soils, sands and clays, which almost entirely bury the indurated rocks of Humboldt county, belong to the Kansan age. Even where the soil is thinnest, and underlying limestones come nearest to the surface, even there, remains of the work of the old Kansan ice sheet are not lacking. From the reports of well diggers we may gather that, in some parts of the county at least, a deposit older still intervenes between the Kansan and the limestone rocks below. Such deposits doubtless represent the famous pre-Kansan formations revealed, with more or less clearness in various parts of the state, elsewhere. Our data for Humboldt county, however, are insufficient to justify more than this simple mention, and in what follows we may consider all the drift underlying the Wisconsin as Kansan.

In Humboldt, as elsewhere, the Kansan drift takes on different aspects, according as it has or has not been exposed to the action of the elements. Originally in large part a blue clay, where long exposed to the weather it becomes brown or ferruginous. In many localities the upper portion of the Kansan consists of beds of sands and gravels, and such deposits are always reddish-brown in color, very unlike the pale yellow of the overlying Wisconsin clay. It follows from this that the natural exposures of the Kansan are brown, while the same formation may and does furnish the blue clay of the well digger. In the particular case before us the only natural outcrops of the Kansan occur along the river valleys, as already intimated, and here they seem to represent the drainage deposits left by the abundant south-flowing waters of the retreating glacier; they are the Buchanan gravels and alluvial sands. The sandy plains about Bradgate, the flat valley opposite Rutland, the town site of Humboldt, the sandy fields south of the mouth of Indian creek, all represent the

old Kansan alluvium, over which the later drift passed like a shadow, leaving only here and there the slightest impress. On the other hand there are no finer exposures of Buchanan gravel than may be seen in the gravel pits of the Minneapolis & St. Louis railway, near the west end of the railroad bridge across the east fork, or one half a mile further west, where the gravel is excavated for road material to improve the public highways. Similar exposures occur at several places along the river valley in Beaver township, as near the center of section 17, on the north side of Coon creek, near the mouth, in the northwest quarter of section 20, and even on the top of the hill in the northwest quarter of section 30. In all these cases we find the peculiar orange-brown, ferruginous, coarse sand and gravel formed from decomposing pebbles, which are to-day so near disintegration that they crumble in the fingers of the collector.

The extent of these deposits is very difficult to estimate. They probably underlie in considerable depth all the upland south of Dakota City and between the two forks of the Des Moines, south to their union. Reports of deep wells indicate the presence of the gravels all over the western portion of the county. At the Gilmore quarry there is an exposure of the same deposits, about three or four feet in thickness, and along the road running east and west immediately north of the quarry there is a prominent ridge of sand and gravel, referable to the same origin. The ridge north of what was once Owl lake is also chiefly Buchanan gravels and wind-driven sand.

Elsewhere our knowledge of the Kansan is limited to reports of wells; but these uniformly report blue clay, in greater or less thickness, below the Wisconsin or "gravel dirt," so that we may reasonably infer the presence of the Kansan drift over the whole county.

WISCONSIN DRIFT.

Except as noted, this is the surface deposit over the whole county. It is generally pale yellow, almost white in color

when dry, contains abundant calcareous pebbles, generally small, but sometimes of considerable size, when they often show to perfection the evidence of glacial planing. The granite bowlders are also fresh, untouched by decomposition or decay, generally of medium size, those of reddish color predominating. The deposit is not only remarkable for uniformity of composition, but of distribution also. Nowhere very thick, yet it covers the surface nearly everywhere, conforming generally very closely to the eroded features of the underlying Kansan. Hillsides are often as well and evenly covered as hilltops, showing that erosion since the Wisconsin has been slight. For these reasons natural exposures of contact between the two drift sheets are seldom to be observed. One such, however, is at present shown near the mouth of Coon creek, and one east of Rutland, just north of the ford on the west fork. Railway cuttings and road gradings sometimes here serve the purpose of the student, but unhappily in Humboldt county there is little grading of any kind necessary, and artificial exposures are not numerous. The railroad cuts immediately north of Humboldt show fine exposures of Wisconsin, here probably twenty feet in thickness. When fresh these excavations probably revealed the contact in question, but at present, in consequence of erosion from rains, all such features are obliterated. An exposure of typical Wisconsin may be seen immediately south of Rutland, where the road leading south has recently been graded, directly up the face of the hill. Similar exposures are thus in evidence in various parts of the county. From what may be observed in cuttings, and from well records, the thickness of the Wisconsin probably nowhere in this county exceeds fifteen or twenty feet, and is often very much less. It is but a thin veneer, as said before, everywhere immediately capping the Kansan. At Livermore, at the site of the town well, the surface clay does not exceed two feet in thickness; near the mouth of Beaver creek it is about sixteen feet in thickness, where the underlying Kansan is some seventy feet in depth; an exposure in

Weaver township showed for the same deposit a thickness of perhaps eight feet, humus and all, while along the alluvial plains by the river, as already remarked, and sometimes on the upland, there is no trace of the pale deposit at all, only here and there a cluster of smooth, hard, recent bowlders to give evidence that the Wisconsin ice once did in reality visit the locality.

Taking the Pleistocene deposits throughout, their average depth is hardly fifteen feet. The greatest depth reported to which a well has been sunk, is 135 feet. This is the well at Livermore. The drift here is 132 feet. South of Owl lake wells 100 to 120 feet deep encountered no rock. At Renwick rock is 125 feet below the surface of the ground. In the west half of the county, as already stated, the depth of the drift is far less, ranging from nothing to twenty or sometimes fifty feet. As far as now known the rocky foundation of the county is strikingly even and uniform, dipping to the east and south only a little more rapidly than the clayey mantle of the drift.

SOILS.

The soils of Humboldt county are strikingly uniform. Except the alluvium along the rivers, which in some parts is sandy, we have in general the rich black loam of the prairie, of great depth and of seemingly exhaustless fertility. The topography of the Wisconsin lends itself everywhere to the formation of marsh; and sedges, swamp grasses, rushes and mosses seem to have covered this latest till from the very beginning. The perennial moisture checked the waste by fire, and the amount of organic material and vegetable detritus, contributed to the surface soil has been immense. The present methods of drainage bringing all nature's marsh lands under the plow, place at the service of the farmer the accumulated wealth of ages. Nor is this all. The unusual amount of lime, pulverized or in rapidly decomposing pebbles which form so prominent and conspicuous an element in the Wisconsin soils, seems to offer an exceptional foundation for the cul-

tivation of cereals of every description, especially wheat. Humboldt county, therefore, joins itself to the great wheat raising region of the world, a region which stretches far north and west, including, in the United States, northern Minnesota and the Dakotas. Along the rivers there are a few steep banks and sharply eroded, short ravines, which are unsuited to cultivation, and have been wisely left to grow up to timber, but aside from these limited areas, once the present system of drainage is completed, there will be left of untillable land in Humboldt county scarcely an acre.

ECONOMIC PRODUCTS.

The natural products of Humboldt county include limestone, suitable for building purposes and for the manufacture of lime, native wood for fuel, and peat These we may now consider briefly.

Building Stones.

The exposures of Kinderhook and Saint Louis limestones already described have, from the earliest settlement of the county, furnished an abundant supply of rubble-stone, much of it of a superior quality. From Dr. Welch's quarry were taken stone for erecting the fine buildings of Humboldt College; this in the early history of the town. From the same quarry came the rock for the piers of the bridge of the Chicago & North-Western railway, erected in 1881, south of Dakota City. In the city of Humboldt quarries are common, and numerous handsome stone business blocks attest the activity and energy of its people. Indeed, it is said that the rock necessary for the erection of the walls of a business house in Humboldt may often be obtained in excavating the cellar. A beautiful stone schoolhouse, of which we present an illustration in figure 16, attests the excellence of the local supply for quarry stone. Mr. Bull's quarry is the only one now operated in the city. The rock over the area uncovered has been removed, down to what appears to be the old surface

FIG 16. Schoolhouse at Humboldt—St. Louis Limestone.

of the Kinderhook limestone. According to reports given by workmen the deeper layers are less valuable. In fact, here, as often elsewhere, the strata of quarry rock are not uniform, and for practical use the rubble must be carefully culled.

Reference has been made, also, to the excellent limestone in Weaver township, in the northeast quarter of section 9. No better stone for general use can be found than this. It is a crinoidal limestone, occurs near the surface, and is quarried with little trouble.

The flourishing town of Gilmore uses rock from the Gilmore quarries. This rock, which is certainly, in its upper beds at least, the same as that last mentioned in Weaver township, is widely known, has been quarried and shipped in hundreds of carloads, having the advantages of railway transportation. This quarry is in Pocahontas county. It is mentioned simply to show the possibilities in Weaver township if supplied with equal transportation facilities.

The Stearns quarry, in the northwest quarter of section 3, Corinth township, is another excellent exposure of building stone. The beds here are much heavier than in most of the

neighboring quarries, and rock suitable for bridge piers may be easily obtained in unlimited quantities.

Lime.

Lime has been manufactured from stone taken from all horizons of the Humboldt county limestones. The oolite in particular was at one time extensively quarried at Humboldt for this purpose, a fact attested by several well constructed kilns still standing, but unused. The lime produced serves excellently for local and immediate use, but is said to be ill adapted for shipment, on account of rapid air-slacking. It appears that at present, even for local use, lime manufactured from the magnesian Niagara limestones is generally imported.

Sand.

Sand, suitable for building purposes, is not lacking, and is obtainable at various points along the river. The peculiar bed of white sand referred to on page 135 has been extensively excavated for this purpose, and deserves more thorough exploration.

Clays.

The clays of Humboldt county are not generally well adapted to the manufacture of brick or tile. The Wisconsin contains in general too much lime. Nevertheless, brick making has been successfully conducted at Dakota, and the court house and jail are built of brick, said to have been burned near by. This was many years ago. At present the only kilns operating in the county are at Livermore, where the Stitch Bros. have been busy some three or four years in the manufacture of brick and tile. The clay made use of appears to be Wisconsin. It is found in a marshy region, and close to the surface. Every effort is made to free the clay from pebbles, but, nevertheless, a sufficient number remain to make the manufacture of brick uncertain. Messrs. Stitch manufacture soft brick only, and many of these are rendered worthless by pebbles of limestone, which in process of manu-

facture burn into quicklime. But, notwithstanding all difficulties, the firm manufactures brick, and sells them at the rate of from 200,000 to 300,000 per year. The company is more successful with tile, which require, it appears, less burning. Tile are burned at the rate of 300,000 or 400,000 per year, and the demand exceeds constantly the present capacity of the plant. Ft. Dodge coal is the principal fuel used. Taking into account the unusual difficulties to be overcome, the enterprise is a remarkable success.

Fuel.

The fuel of the pioneer was wood. The forks of the Des Moines and the larger streams of the county were originally, more or less, continuously fringed with native woods. This native forest afforded the early settler at once shelter and fuel in advance of the advent of railways or the possibility of supplies from without. The original trees are mostly gone, but in their places stand luxuriant groves of "second growth," which, by judicious cutting, furnish their owners an abundant supply of the finest fuel, and may continue so to do for indefinite years to come. Besides these natural timber supplies, the results of almost universal tree planting on the farms are now apparent. Everywhere are groves, many containing trees of considerable size, so that the artificial forest of the county to-day furnishes no inconsiderable amount of the fuel used by the agriculturists. Humboldt county can easily raise its own fuel without seriously trenching at all upon its tillable land, at least beyond that which is necessary to afford the shelter of trees to the homes of its people.

The prospect that coal may be mined in the county is not encouraging. The coal measure exposures, as we have seen, are very narrow in extent, and even then are, for the most part, barren. It is possible that coal might be found in one or other of the localities where the coal measure shales crop out, but the chances are that the quantity discovered, if any, would be insufficient to pay the expenses of exploration. At

least, so long as abundant supplies can be obtained with so much convenience in the adjoining county south, it is not likely that much effort will be made to use Humboldt county coal.

There is, however, another natural fuel supply present in considerable amount in the eastern part of the county, which seems to merit greater attention than has hitherto been accorded it. I refer to fields of peat. Almost every marsh in Lake and Norway townships contain peat, in several places in quantity sufficient to be worth considering as a fuel supply. Geologically considered, peat is the youngest member of the coal series, anthracite, soft coal, lignite, peat, *i. e.*, coal is a consolidated peat, peat an imperfect coal. Its combustibility has been abundantly shown in Humboldt county. The draining of Owl lake has left a large body of peat to dry along what was the north shore, and this has recently taken fire and burned over many acres, to the depth of several feet, leaving vast beds of ashes and half-burned organic matter. A similar combustion has recently taken place on the west side of section 2 of Lake township. It will surprise some people to learn that peat has a higher heating power than dry wood. The distinguished chemist, Remsen, estimates the calorific energy of bituminous coal at 75, dry peat at 48, and dry wood at only 28; peat is, pound for pound, 75 per cent better than wood. Unfortunately, in this country, peat has never been widely utilized, and a supply of fuel, which certainly will one day be needed, is now suffering indiscriminate waste.

Water Supply.

The two branches of the Des Moines river are unfailing sources of water supply for the western and central portions of the county. Indian creek, a perennial stream, finds its source in a beautiful spring, Indian spring, which, with a temperature of 54° F., wells up through a bed of white sand, in the Nw. qr. of the Sw. ¼ of Sec. 21, in Corinth township. The spring

is on a level prairie, only about twenty-five feet lower than the highest land in the neighborhood. Wells on the adjoining farms furnish unfailing supplies of water, from a depth of fifty feet. An effort was made some time ago, by filling up the spring, to make the water rise higher. The result was to convert what was formerly a beautiful pool into a miry morass. The spring might be made an attractive resort. Another spring of considerable volume furnishes the principal water supply of the town of Humboldt, and all along the west fork, at least, springs are abundant. However, for the county at large, the water supply is from deep wells, generally sunk in the drift, though, in the western townships, often in the limestone rock, as heretofore described.

Water Powers.

Both branches of the Des Moines afford water power and convenient mill sites. Mr. C. H. Brown owns a fine flouring mill at Dakota, an excellent water power, which has been in use a great many years. A similar power drives the mills of Humboldt. Rutland, as it appears, once possessed a like advantage, and is now attempting to restore it.

In short, from an economic standpoint, the county before us is abundantly furnished with all that may contribute to the wealth and prosperity of a happy people; soil of exceptional depth and fertility, remarkable even in fertile Iowa, waters abundant and pure, springs and perennial streams, limestones to furnish building material for all time, native groves to beautify every stream and furnish, if cared for, fuel for generations to come, planted groves that well might make the prairie wooded,—such a county needs no praise; it is itself its own encomium.

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FORESTRY NOTES FOR HUMBOLDT COUNTY.

A glance at the accompanying list of forest trees native to Humboldt county is sufficient to show that we have here nearly all the species commonly occurring in other more definitely wooded regions of the northern United States. This of itself is enough to refute the old but yet persisting opinion which would maintain that the prairies have in themselves, in their very make-up, something inimical to the growth of woodland species. Humboldt county is a typical prairie county, and yet certain localities were, until recently, covered with heavy timber. Walnut, oak, elm, linden and ash grew to dimensions suitable for the mill. Trees eighteen to thirty inches in diameter were not uncommon. These were in the rich soil of the creek and river valleys, the finest, perhaps, near the mouth of Beaver creek. Certain species of trees have been planted over the prairie and have, in the main, done well; but the drought of recent years has destroyed some of those thought to be most suitable for prairie planting, notably cottonwoods and poplars. But trees will grow in Humboldt county anywhere, if planted and protected. The fact remains, too, that the trees in every way best adapted to general planting in Humboldt county are those originally found growing there. For ornamental trees, for instance, none are more beautiful than wild plums and crab apples, and these are native. Hawthorns and sumac may be used effect-

ively for the same purpose. These will all grow anywhere, and it is a matter of wonder that for decorative purposes they are not more generally employed. The native oaks, hickories and walnuts cannot well be transplanted from the woods, but in good soil, if cultivated, they grow from the seed much more rapidly than is generally supposed. The hickories, and especially the bur oaks, have, in Iowa, been so far proof against all drought. The bur oak grows slowly, but it is by all odds the hardiest tree we have. Since our agriculture is now becoming established, our occupancy of the country permanent, as we begin to build permanent houses and barns, it is at least time to inquire whether our temporary tree planting, which involved the use of soft woods, rapid growers only, should not now begin to give way to something permanent and enduring? Is it not proper to introduce in appropriate places on our farms, and especially about our homes, trees of slow growth indeed, but trees which will endure to the enjoyment and shelter of the generations to follow us, which shall form part of our real estate, permanent, abiding as the soil itself? In the older parts of the world, primeval forests are few; all, or nearly all, of the present forests are artificial. We are rapidly, in the United States, approaching a condition of affairs when the same thing will here be true, and trees of the more valuable sorts will characterize, not forest reservations only, but be, in fact, a part of the product of every well tilled farm. When that time comes the trees which the pioneer found growing in each locality will doubtless be found the most valuable species for permanent and profitable plantations.

The peculiar distribution of forest and prairie in Humboldt county to-day corresponds probably pretty closely with that discovered by the earliest civilized residents. Before the advent of civilization the principal check to the general extension of forest domain was found, not so much in the variation of the soil, as in the prevalence of prairie fires. The trees were limited to the occupancy of those parts of the country

less severely visited by the perennial conflagrations. The present distribution of woodland and prairie in Humboldt county affords a striking illustration of this fact. Sometimes prairie fires came late in the fall, after the frosts had thoroughly killed the prairie vegetation, or in the spring, after the snows were nearly gone. They moved in general from the west. In such conflagrations seedlings and small trees universally perished, where exposed to the fires' full heat. Special localities, however, favored trees. Thus a sandy or rocky hilltop afforded no fuel, and the young tree survived. Lowlands generally were unfavorable to fire. Sometimes too wet to burn; sometimes subject to overflow, and deposition of new soil covering all fuel. In Humboldt county, as the present distribution of the timber shows, it was sometimes the river, sometimes a marsh, sometimes a steep bank, sloping to north or east, and on this account more moist, longer covered with snow in spring, that gave refuge and respite to the trees. In Wacousta township the woods are mostly east of the river, near Bradgate they are on both sides, protected on the west by bluffs, on the east by swampy or marshy ground. In the central part of Avery, down about to the west line of Rutland, the fires seem to have swept everything on both sides of the stream, crossing readily by the generally low banks. Further east, and in the vicinity of Humboldt and Dakota City, steep bluffs again gave foothold to the woods. The mouth of Indian creek, on the west fork, and the lower valley of Beaver creek, where that stream enters the east fork, offered to the trees the advantage of both conditions favorable to the retention of moisture, the steep bluff and the lowland. There are beautiful groves along the east fork, successors of primeval forest areas, whose existence in the midst of a prairie county must be explained by reference to similar topographic conditions.

The following list of the trees and shrubs of Humboldt county is believed to be reasonably complete. For its accuracy the author is much indebted to the assistance of

Miss Mae Webber, who has long enthusiastically studied the flora of the county.*

Tilia americana L. The Linnwood or Basswood tree; common in all the native groves of the county, and occasionally planted.

Xanthoxylum americanum Mill. Northern Prickly ash. Quite common. Abundant near the mouth of Beaver creek. Sometimes attains a height of ten or twelve feet. Ornamental; otherwise of small value.

Acer saccharinum Wang. Hard maple, Sugar maple. Scarce, occurring chiefly along rocky banks, and in rich alluvial soils.

Acer dasycarpum Ehrh. Soft maple, Silver maple. Common along streams, and everywhere planted for artificial groves. For this purpose the most useful tree in Iowa. Its rapid growth and hardy vigor adapting it particularly to our prairie conditions.

Negundo aceroides Moench. Box elder. Common everywhere along streams, also universal in cultivation, though not so general in plantations as the last species. Less hardy, also, than the Soft maple; more sensitive to drought and to winter changes.

Rhus glabra L. Sumac, Smooth sumac. Common on hillsides near the wooded regions. Small in stature; not attaining anything like the vigor exhibited in some quarters, but manifestly holding its own.

Robinia pseudacacia L. Locust, Black locust. Common in cultivation, or escaped from early plantings. Probably not indigenous.

Gymnocladus canadensis Lam. Kentucky coffee tree. Planted for ornament. Not native.

Gleditschia triacanthos L. Honey locust, not native. Occasionally seen in cultivation.

Prunus americana Marsh. Wild plum. Common.

Prunus virginiana L. Choke cherry. Not uncommon along the rivers, especially in rocky places.

*The nomenclature in this list is that of Gray's Manual, 6th ed.

Prunus serotina Ehrh. Wild cherry. Not common. Here and there along the rivers.

Pyrus coronaria L. American Crab apple. Everywhere common on hillsides, especially in the neighborhood of the streams. Sometimes forming small clumps or thickets where there is no other tree, by the smaller streams, or even in ravines. One of our most delightful native trees. The American forest shows nothing more beautiful, nothing sweeter than a crab apple in the perfection of its bloom.

Cratægus coccinea L. Common hawthorn. Not rare along the sandy flood plains of the rivers.

Cratægus coccinea L., *var. mollis*, Torr & Gray. Red hawthorn. Not rare. Recognized in late summer by its large, edible, bright scarlet fruit.

Cratægus tomentosa L. Occurs sparingly in the southern part of the county, Reported, also, from the northeastern corner of the county. Fruit larger, dull red or orange.

Amelanchier canadensis Torr & Gray. Shadbush, Service berry, Juneberry. A few along the river near Beaver creek.

Cornus asperifolia Mx. Dogwood. Reported not rare.

Cornus stolonifera Mx. Red-osier dogwood. Reported from the southern part of the county.

Sambucus canadensis L. Common everywhere, especially in hedgerows, gardens, etc.

Viburnum lentago L. Black Haw, Sheep berry. Not infrequent in thickets along the streams.

Viburnum prunifolium L. Black Haw. Occurs sparingly with the other. Both species of haw are becoming extinct in Iowa, unable to endure the close pasturage, and the browsing to which, in our torrid summers, all shrubby vegetation is more and more subjected.

Cephalanthus occidentalis L. Buttonbush, not rare in wet places by the rivers, and on sandy islands.

Fraxinus americana L. White ash. Not uncommon in all the wooded region, and not infrequently planted. A most valuable tree.

Ulmus fulva Mx. Slippery elm, Red elm. Not uncommon.

Ulmus americana L. American elm, White elm. Very common along all streams, and now everywhere planted. Specimens south of "Owl lake" were observed, eighteen inches in diameter. Our most valuable street and general shade tree.

Celtis occidentalis. Hackberry. Rare. A few reported from the southern part of the county.

Morus rubra L. Not indigenous. Planted in some localities for hedgerows and wind-breaks, where it appears hardy and efficient.

Juglans cinerea L. Butternut, White walnut. Not uncommon along hillsides and by the streams. This tree grows rapidly from the seed, in good soil, and would make a valuable shade tree as part of a plantation.

Juglans nigra L. Black walnut. Not common. Reported as once abundant along all the streams of the county. This species also comes on, in good soil, rapidly from seed, but does not bear transplanting.

Carya alba Mott. Hickory. Small trees of this species are not uncommon on higher ground, in the wooded regions, especially along the east fork. A very hardy species. Stands the drought and abuse of all kinds remarkably well, and furnishes most valuable timber for wood.

Carya amara. Bitternut, Pignut. Common in similar locations with the last species. By far less valuable.

Betula papyrifera Marshall. White birch. Occurs in cultivation, and is reported "abundant along the Boone river, east." Perhaps comes within the limits of the county in the northeast corner.

Corylus americana Walt. Hazlenut. Very common, especially on hillsides.

Ostrya virginica Wild. Ironwood, Hop horn-beam. Occurs sparingly along hillsides, on both forks of the river.

Carpinus caroliniana Wild. Ironwood, Blue beech, Water beech. On rocky banks, near the water's edge. Reported formerly common. Certainly less common than the preceding.

Quercus alba L. White oak. Not uncommon on the high ground near the rivers.

Quercus macrocarpa Michx. Burr oak. Very common, by far the most common oak in the county, as it is the most hardy. Found everywhere, in good soils and poor. A fine grove of them in the sandy soil north of the ford in Rutland township, section 34. Often makes a grove of more or less stunted trees, far from any other trees, and so everywhere constitutes, toward the west especially, the van-guard of the forest. Excellent, both for wood and lumber, for all purposes requiring strength and durability. A tree of slow growth.

Quercus coccinea Wang. Scarlet oak, Black oak. The form occurring is that common throughout Iowa. This is neither *Q. coccinea*, as described, nor yet *Q. coccinea*, var. *tinctoria*. The scales of the cup are yellowish, downy, instead of being glabrate and close adpressed, as the type should be. Common in all the native groves.

Quercus rubra L. Red oak. Not infrequent on uplands in all the wooded districts. Large trees of this species are reported from the valley of Beaver creek, and from the east fork.

Quercus coccinea Wang., var. *tinctoria* Gray. Is reported to have been represented, not long since, by large trees.

Salix nigra Marsh. Black willow. Common along the streams.

Salix cordata Muhl. Reported rare; "a few specimens only."

Populus tremuloides Michx. American aspen, Quaking asp. Common all through the wooded portion, especially at the edge of the woods, and in low grounds.

Populus grandidentata Michx. Large-leafed aspen, poplar, Quaking asp. Common on high ground everywhere in the native groves. A tree of rapid growth, short-lived, but useful as a nurse for more valuable and enduring species.

Populus monilifera Ait. Cottonwood, Necklace poplar. Common throughout the county, and commonly planted. Surprising to relate, some of the planted trees in the higher situations have, in these later years, succumbed to drought.

Populus dilatata Ait. Lombardy poplar. Is commonly planted. The species is not native to the United States, and, although a favorite ornamental tree in many localities, is, nevertheless, short-lived, and, on the whole, unsatisfactory.

Juniperus virginiana L. Red cedar, Juniper. Reported formerly common; not rare.

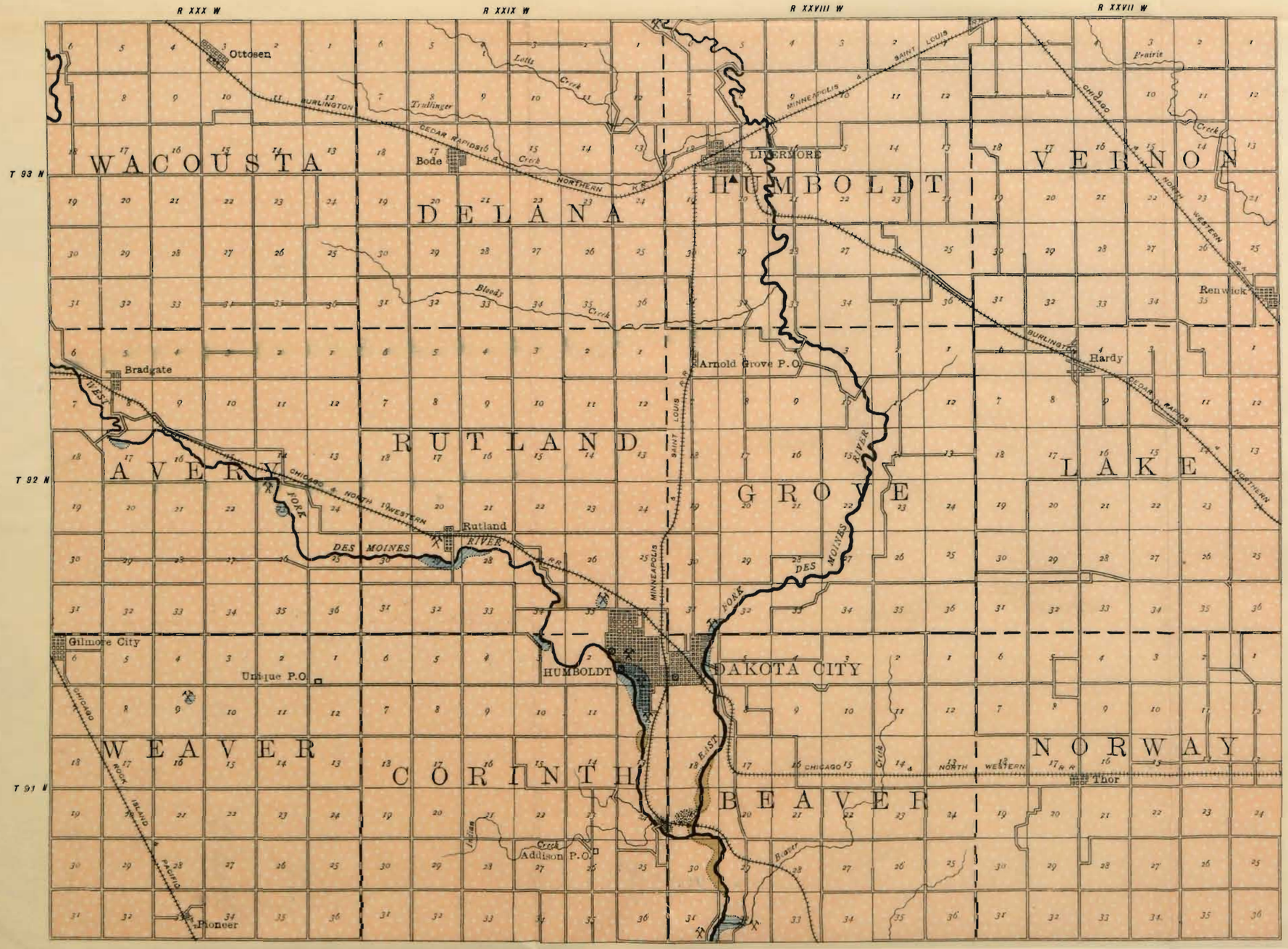
IOWA GEOLOGICAL SURVEY

MAP OF THE SURFACE FORMATIONS OF HUMBOLDT COUNTY, IOWA.

BY

T.H.MACBRIDE

1899.



Scale 1:250000

1 0 1 2 3 4 5 Miles

1 0 1 2 3 4 5 Kilometers

LEGEND

GEOLOGICAL FORMATIONS

- WISCONSIN DRIFT
- DES MOINES (Coal Measures)
- SAINT LOUIS
- KINDERHOOK

INDUSTRIES

- QUARRIES
- COAL MINES
- CLAY WORKS
- LIME KILNS
- BUCHANAN GRAVEL

IOWA LITHO. CO. DES MOINES.

DRAWN BY F.C. TATE